

Usability of national reporting data as a reference for generic unit processes

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Abstract

Background, aim and scope The reliability of the results of Life Cycle Assessment (LCA) studies is highly dependent on the appropriateness of the data that are used for Life Cycle Inventory (LCI) modelling. In practice, the modelling of background systems is commonly based on generic data—which are often outdated and rarely provide information on the current situation in a representative manner. Meanwhile, an increasing number of policy directives, international agreements and national legislations to regulate the reporting of environmentally relevant data for companies and economies entered into force over the past few years. The purpose of this study is, therefore, to compare data reported in such a manner from selected sources with detailed existing generic LCI data and to evaluate their usability as a reference for LCI modelling on a unit process level. Depending on the scope of the selected reports, the study reflects considerations on a national scale.

Materials and methods Selected data from an existing LCI study are compared with data from environmental reporting approaches, in order to analyse the degree of variation between generic data and related reporting data. Two selected reporting obligations are described in more detail and characterised methodologically from the LCI perspective: (1) the ‘United Nations Framework Convention on

Climate Change’ (UNFCCC) and (2) the European Union’s Directive on ‘Integrated Pollution Prevention and Control’ (IPPC). The national data that can be derived from these two reports are compared with generic LCI data provided by the ‘Environmental Profile Report for the European Aluminium Industry’ from European Aluminium Association (EAA).

Results The number of processes and elementary flows is originally different across the three data sources due to divergent system boundaries. Therefore, in order to perform the comparison against a common reference, the analysis is done at a unit process level: only the emissions featured in all three sources are analysed (i.e. emissions of CO, CO₂, PFCs and SO₂ resulting from anode production, electrolysis and cast house). The comparison of data from this limited number of processes shows differences across the three data sources.

Discussion A key reason for the differences is the divergent scopes considered in the different data sets (i.e. geographical coverage and time period). Still, despite the differences in scale and scope, the deviation between the data from IPPC and EAA is found to be within reasonable and acceptable margins—especially when also the different technological conditions are considered. Thus, the dataset of EAA is judged to be reliable—within its original scope. However—with the exception of PFCs—the differences between the data from the EAA report and those derived from UNFCCC cannot be explained this way.

Conclusions This study exemplifies drawbacks and opportunities of the usability of data from environmental reporting as a national reference for existing LCI data. By comparing reporting data and existing LCI data, deviations can be explained and inappropriate or outdated data can be detected. For this procedure, knowledge about temporal coverage and individual system boundaries of the data is

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required. Also, expert knowledge about the processes themselves and technologies applied within these is indispensable, in order to explain differences between data sources.

Recommendations and perspectives From an LCA perspective, the referencing of generic LCI data provides an important informative basis to focus data collection and update. However, inconsistencies due to the limited amount of elementary flows covered in reporting still need to be resolved—keeping in mind the individual aim of the study. Additional data from upcoming Pollutant Release and Transfer Registers provide a promising perspective.

Keywords Aluminium · Appropriateness · Data availability · Environmental reporting · EPER · IPPC · LCI modelling · National Inventory Report · Reference data · UNFCCC

1 Background, aim and scope

Life Cycle Assessment (LCA) is an important measure for the development and application of certain instruments for supporting sustainable development, such as Integrated Product Policy (IPP) or Environmental Product Declaration (EPD) (Schminke and Grahl 2007). However, a brisk implementation and use of LCA is often impeded by a lack of actual and reliable Life Cycle Inventory (LCI) data—or, more precisely, by the ignorance about the appropriateness of generic data.

Generic data are often outdated and only approximately meet the intended geographical and technological needs (Guinée 2002; Huijbregts et al. 2001). Nevertheless, the application of generic LCI data has become a common procedure in life cycle studies as the acquisition and regular actualisation of specific and dedicated data is both time and cost intensive. The modelling of life cycle processes that address specific concerns in a ‘foreground system’ is a noteworthy exception as in this case individual and extensive collection and validation of LCI data is indispensable (Curran 2007). But, for ‘background systems’ within such LCI models, generic data are usually used (Azapagic 1996; Tilmann 2000). The generic data used commonly have to fulfill only rather general requirements such as

- representativeness for a certain geography and technology,
- being up-to-date/regularly updated and
- proof of validity.

In parallel, an increasing number of policy directives, international agreements and national legislations have

entered into force during the last years that regulate the reporting of environmentally relevant data for companies and economies. As a result, an increasing number of data for emissions from industrial activities are being generated, made available and updated regularly. These data are expected to be based on comparable requirements as LCI data needed to model background systems. Thus, they should bear the potential to be used for life cycle modelling or as complements to existing gaps in life cycle studies (Boguski 2000). However, environmental reporting often focuses on companies and economies rather than individual products. Furthermore, reporting data generally comprise only direct emissions by a selective number of elementary flows. Thus, from a life cycle perspective, an immediate utilisation seems not to be appropriate (Warsen and Bauer 2007), but environmental reporting data is assumed to be applicable as national references for existing LCI data. However, the question remains whether and to what degree data from the different sources actually vary and how these variations might be explained. To answer this, in this paper, selected data from an existing LCI study are compared with data from two environmental reports—using the production of aluminium as an example.

2 Materials and methods

First, the process of environmental reporting is described generally, in order to get an idea of the possibilities and drawbacks of the data from environmental reporting in the context of this study. Following this, selected reports are described in more detail and characterised methodologically from the LCI perspective.

2.1 Environmental reporting data

Environmental reporting is a measure for both surveying the success of procedures on emission reduction and corresponding decision-making on the administrative level. It also serves information purposes for other interested parties. In general, two types of reporting can be distinguished: The first type is based on generic emission factors, which are related to specific outputs using expert knowledge (i.e. a top down approach). The second type builds on primary measured data and mainly covers larger point sources (i.e. a bottom-up approach). General criteria of environmental reporting can be characterised as

- quantification of emissions that result from industrial activities,
- existence of a methodological framework with guidelines for a consistent acquisition of emission data,

- continuous periodic acquisition and documentation/inventory of emission data,
- permission of public access to the emission data/inventories.

Based on this, several reporting obligations and environmental reports are considered to bear the capability of serving suitable data for the integration into the LCI context, e.g. Global Reporting Initiative (GRI), Convention on Long-Range Transboundary Air Pollution (CLRTAP), United Nations Framework Convention on Climate Change (UNFCCC), European Union's Directive on 'Integrated Pollution Prevention and Control' (IPPC) and Eco-Management and Audit Scheme (EMAS). For the purpose of this study, two particular reporting obligations have been selected, namely UNFCCC and IPPC. Figure 1 gives a simplified overview of the way of data generation for these two different data sources. The UNFCCC methodology—a typical example of a top down reporting approach—is based on generic emission factors and related activity rates. In combination, these are used to derive emission patterns of countries on a high aggregation level and aim to describe entire flow rates of a country's emission. In contrast to this, data generation under the legislation of IPPC is based on primary emission data that are aggregated for individual plants, and thus represents a bottom-up approach.

NIR The United Nations Framework Convention on Climate Change has the goal to set an overall framework to prevent or at least to minimise the effects of industrial and

other emissions of carbon dioxide and other greenhouse gases (GHG) to the climate system. The convention entered into force on 21 March 1994 and has now (2007) been ratified by 191 countries worldwide. A climatic measure of the convention is the 'Kyoto Protocol' that entered into force on 16 February 2005. It significantly strengthens the Convention by committing 'Annex I Parties' (usually more developed countries) to individual, legally binding targets to limit their greenhouse gas emissions. One hundred and seventy-five countries have ratified the Protocol to date, 41 of them classified as Annex I Parties. GHG emission data from 'Annex I Parties' are published annually, both individually by countries and in summary by the UNFCCC secretariat. Data collection under the legislation of UNFCCC is based on generic emission factors. These factors are used to derive emission patterns of countries on a high aggregation level and aim to capture entire flow rates of countries' emissions. The UNFCCC reporting mechanism is thus of special importance for LCI modelling, in particular where the focus is on greenhouse gas emissions. However, it should be noted that the number of elementary flows reported under the convention is limited to six compounds—i.e. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halocarbons (HFCs, PFCs) sulphur hexafluoride (SF_6), ozone and aerosol precursors. The industrial sectors that are reported on under the UNFCCC are consistent with the 'Nomenclature Statistique des Activités Économiques dans la Communauté Européenne' (NACE) classification (Eurostat 2007). Binding guidelines that have to be considered for reporting to UNFCCC are available from

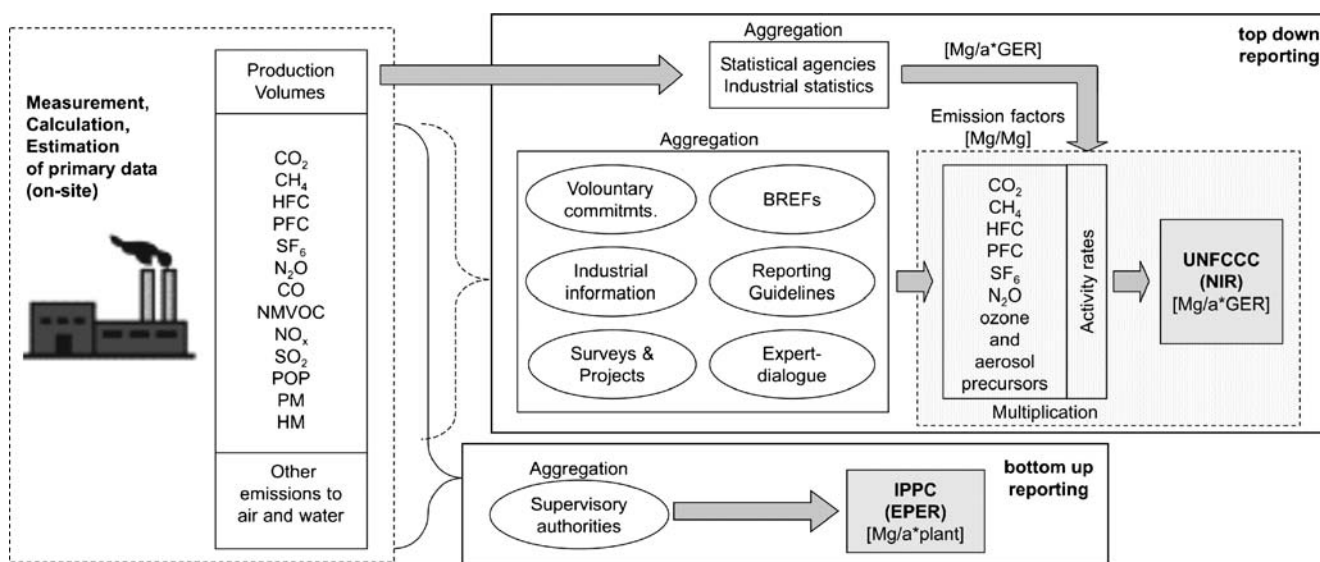


Fig. 1 Generation of reporting data for UNFCCC and IPPC

the ‘Intergovernmental Panel on Climate Change’ (IPCC 1996, 2001). There are two different classes of emission factors available from environmental reporting under UNFCCC.

1. Default/standard emission factors are given by the guideline documents as parameters for first level estimations. These data are valid on a global scale and are based on lower quality requirements. Ranges are supposed to serve as indicators for validity checks of estimations that are based on more detailed methods (‘country-specific’, see below).
2. Country-specific emission factors can be derived directly from National Inventory Reports (NIR) for emissions that are reported to UNFCCC for national considerations. These data correspond to a high level of detail and fulfill advanced requirements on data quality. A NIR has to be published yearly by all Annex 1 Parties under the Kyoto Protocol to the Convention.

EPER In 1996, the European Union (EU) adopted a set of common rules for permitting and controlling industrial installations with the Directive 96/61/EC concerning ‘Integrated Pollution Prevention and Control’ (IPPC Directive) (European Commission 1996). Being aware that industrial production processes account for a considerable share of the overall pollution in Europe, the main target of the IPPC Directive is to minimise pollution from various industrial sources throughout the European Union (EU27). An essential measure is the authorisation of industrial installations from authorities in the EU countries that are in compliance with the requirements of the Directive. Thus, about 50,000 installations (new and existing) in Europe will need to obtain ‘environmental permission’ by 30 October 2007. Besides the official authorization procedures, public participation is another fundamental principle of the IPPC Directive. As a consequence of Decision 2000/479/EC on the implementation of a European pollutant emission register (EPER) (European Commission 2000a), a public access to the emission data that are reported by the member states is granted (Europäisches Schadstoffemissionsregister 2007). Due to the current guidelines (European Commission 2000b), the amount of substances to be reported is up to 50 single substances and sum parameters, distinguished as emissions to air (37) and water (26). In practice, the number of reported flows is dependent on the validity of specific thresholds (European Commission 2000b), i.e. rather limited if applicable. Relevant production categories are defined in the ‘Nomenclature of sources of emissions—Process list’ (NOSE-P) (European Commission Office for Official Publications 1998). Reporting of

emissions under the legislation of IPPC requires the acquisition of emission data for plants within each member country. Due to the methodological framework applied, these data do not only correspond to emissions from a specific process, but do also aggregate flows that result from up- and downstream processes within a plant.

2.2 Characterisation of reporting data from the LCI perspective

To be comparable, the data from environmental reporting have to be transposed to the LCI context. For this, the methodological requirements of the two selected reports are characterised qualitatively in terms of the methodological framework of LCA (International Organization for Standardization 2006a, b). Table 1 reveals selected properties of data from environmental reporting which relate to central terms of LCA.

Appropriateness is understood as the degree of suitability of a data set for a certain application. Within LCA terminology, this means the overlap of a given process/system description with the system under study (Rydberg et al. 2005). Thus, in this study, the description of the appropriateness of reporting data is based on parameters that describe the scope of these, namely, ‘time period’, ‘update’, ‘geographical coverage’, ‘system boundary’ and the ‘number of elementary flows’.

Completeness is understood as a measure for the characterisation of the reliability of a data set. For the description of the completeness of reporting data, the ‘technology coverage’ and ‘representativeness’—as defined by ISO 14044 (International Organization for Standardization 2006b)—but also the ‘level of aggregation’ (horizontal and vertical) must be specified.

Availability is a technical criterion rather than a methodological one. Nevertheless, both the accessibility and the format of the data are also important parameters for the characterisation of reporting data.

Obviously, the reporting data under study are likely to fit for LCI purposes. However, the complete lack of information on input flows in both reports, as well as especially the limited number of elementary flows that are provided by NIR, must be seen as significant drawbacks for the appropriateness in the LCI context.

3 Example—production of aluminium

In order to exemplify the comparability of data from the selected environmental reports with existing LCI data, the production of aluminium is chosen as an example.

Table 1 Characterisation of NIR and EPER in methodological terms of LCA

Criteria	Parameter	NIR	EPER
Appropriateness	Time period	2004	2004
	Update	Annual	3 years
	Geographical coverage	Germany	Germany
	System boundary	Unit process	Gate to gate
	Number of elementary flows ^a	6 (air)	50 (air and water)
Completeness	Technology coverage	Specified sporadically	No specification
	Representativeness	High	High
	Aggregation horizontal	National	Site specific
	Aggregation vertical	Process	Plant
Availability	Data access	Good; report online (.pdf)	Very good; inventories online (Excel interface)

^a Including sum parameters

Key features that make it suitable to show the comparability are:

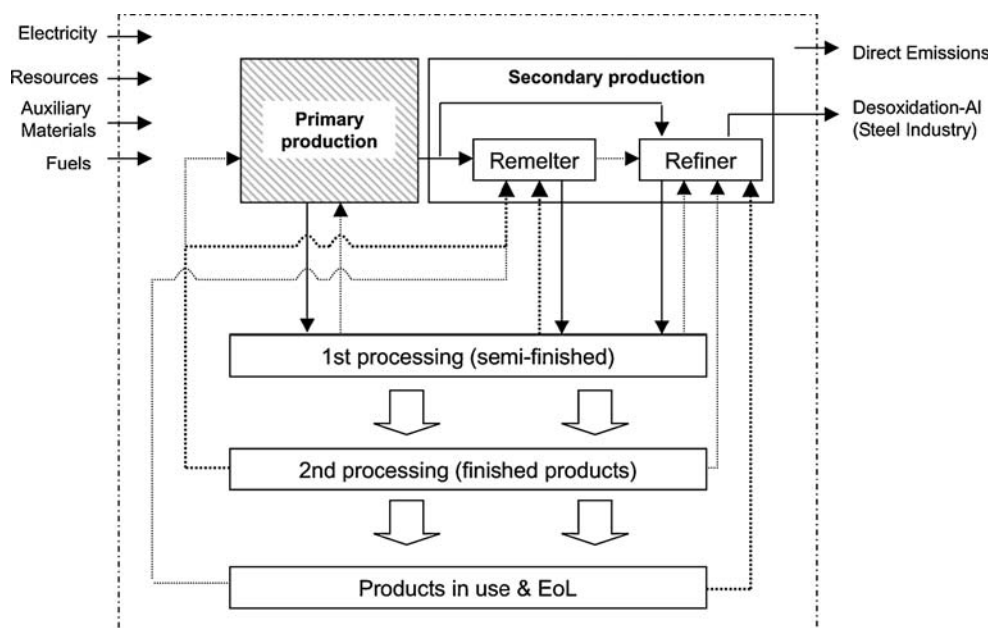
1. Relevant processes are a mandatory subject of reporting to both reporting obligations—with particular relevance to Germany. Thus, it is certain that reporting data are available for comparison (at least in principle).
2. Comparable LCI data are available, based on a thorough LCI reference, that represent a process chain that is modular on a high level of disaggregation. This is mandatory in order to allow a direct comparison, as reporting data do not generally relate to individual products but also to industrial processes.

Aluminium is a material that can be recycled and re-used as often as necessary nearly without any loss in quality. Depending on an adequate collection system, it can be assumed that about 96% of the original material can be recycled after use (Frees 2008; Martcheck 2006). As the amount of aluminium in the economic circulation increases steadily, the importance of secondary production is expected to rise in the future. In contrast to secondary production, smelting of primary aluminium is characterised by a higher electricity demand (Koch and Harnisch 2002; Organization of European Aluminium Refiner and Remelters). Furthermore, emissions that are emitted directly by processes of the primary production reach higher levels than emissions from the secondary supply chain. Nevertheless, primary production is still a relevant source for aluminium as a raw material. In 2006, a total of 515,500 Mg aluminium was produced by the German primary aluminium smelters, while secondary smelters produced 795,700 Mg of recycled aluminium (Wirtschaftsvereinigung 2005). Figure 2 shows a general flow chart of the aluminium life cycle. During the use phase of the aluminium life cycle, its relatively low weight compared to other material holds a potential to reduce overall energy consumption. However, the ‘use phase’ is not part of this study.

The aluminium industry plays an important role in the German economy and displays a high level of penetration into a multitude of other industrial branches. In Germany, aluminium is produced or processed in about 600 plants that gave direct employment to 73,000 people and delivered a turnover of about 15 billion euros in 2006 (Gesamtverband der Aluminiumindustrie 2007). More than two-thirds of the turnover was attributable to the production of raw aluminium and aluminium semi-finished products. Main markets for aluminium products are in the transport, building and construction, packaging and mechanical engineering sectors. Other applications *inter alia* include electrical engineering and the iron and steel industry.

According to estimates based on the methodology of IPCC (2001), the production of primary aluminium is a relevant source of greenhouse gas emissions in Germany (Umweltbundesamt 2006). Thus, under NIR regulations, there is a need for national reporting on emissions from this industrial activity. This also applies for reporting under the regulations of EPER. According to European Commission (1996; Article 1 in conjunction with Annex 1 (2.5)): ‘Installations (a) for the production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes (b) for the smelting, including the alloyage, of non-ferrous metals, including recovered products, (refining, foundry casting, etc.) with a melting capacity exceeding 4 Mg per day for lead and cadmium or 20 Mg per day for all other metals’ are a mandatory subject of reporting.

Besides this, comparable LCI data are given by the ‘Environmental Profile Report for the European Aluminium Industry’ (EAA 2000, 2005) that is edited by the European Aluminium Association (EAA). This report provides a comprehensive set of LCI data, representing the production, manufacturing and recycling of aluminium in Europe in 2002 with a high level of transparency and disaggregation. Due to these preferences, the data from the EAA report are

Fig. 2 General flow chart of the aluminium life cycle

an important source for LCI data that are used directly for single LCA studies (Koch and Harnisch 2002), but also as by most of the available LCI databases (e.g. ecoinvent, GaBi, ProBas, Umberto).

4 Results

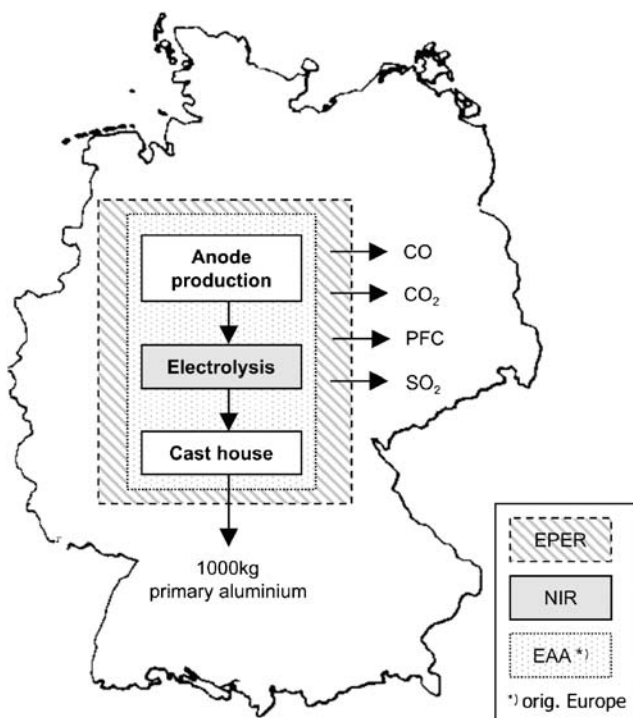
Based on the example of a production of 1,000 kg aluminium, the data from the three different sources are compared below (i.e. (a) EAA; (b) NIR; (c) EPER).

4.1 System boundaries

For the intended comparison of LCI data with data from environmental reports, both types of data need to share a common base of comparison. Thus, the processes—representing the production of aluminium—that are provided by EAA, NIR and EPER are integrated into the system boundary as shown in Fig. 2. Furthermore, the number of comparable elementary flows is determined. Due to this, the data that are compared in this study are based on system boundaries as shown in Fig. 3. The time period and geographical coverage are both predefined to activities in Germany in 2004 due to the methodological prerequisites of the reporting data. Data from EAA have to be adapted to this context, manually.

Processes The system boundaries of the reporting data are predefined due to the methodological requirements from the different reporting guidelines. Thus, NIR

contains emission factors on a unit process level that correspond solely to emissions from electrolysis, whereas, data from EPER are generally based on gate-to-gate considerations and represent emissions of possibly all installations inside the plant, i.e. mainly anode production, electrolysis and cast house. Finally, data from the EAA study stand for even higher aggregated emissions

**Fig. 3** System boundaries for comparison of data

that occur directly from anode production (including preparation of pitch and coke), electrolysis and cast house. For this study, data regarding the electrolysis are used as the basis for data comparison, as these represent the ‘lowest common denominator’ of the three respective sources, i.e. this information is available in all three datasets.

It should be noted that both EAA and EPER also provide additional data on related processes such as operations for secondary production. However, within EPER, this type of additional data is only reported for a limited number of facilities, as its reporting depends on the exceedence of critical thresholds.

Number of elementary flows It is conceivable that the number of reported elementary flows will vary between the three sources. There are two reasons for this heterogeneity: First, this is partly a result of the differences in system boundaries discussed above. Second, the numbers of exchanges that have to be reported obligatorily diverge due to the methodological framework and the individual goals of the reporting obligations. To enable a comparability of the data, those exchanges are selected that represent the least common denominator of all possible emissions. Thus, NIR again is seen as the restrictive element as it provides only

emissions of GHG from electrolysis, namely CO, CO₂, PFCs and SO₂.

4.2 Data collection and comparison

Table 2 shows the data that are derived originally from EAA (2005), NIR and EPER, representing air emissions from processes on base of the system boundaries established in Fig. 3. While the emission factors from EAA and NIR are based on aggregated product profiles, the data from EPER correspond to individual emission profiles at a plant level.

To enable a direct comparability, the original emission data from EPER [kg/a] need to be converted into values with a product-reference [kg/Mg Al]. Thus, in column EPER_{pl} of Table 3, emission factors have been calculated as weighted mean values for Germany on base of the site-specific production volumes. Furthermore, considering the system boundary of the data from EPER, it is assumed that electrolysis is the significant source of the four selected emissions inside the plant (Schlimbach 2003). Therefore, in column EPER_{el}, the individual share of electrolysis from these emission factors has been calculated with CO=98%, CO₂=88%, PFC=100%; SO₂=98%. In parallel, the disaggregated figures of CO₂ and CO from EAA have been derived as based on (EAA 2000).

Table 2 Data collected from EAA, NIR and EPER

Substance	EAA	NIR	EPER-sites [kg/a]				
	[kg/Mg Al]	[kg/Mg Al]	A	B	C	D	E
Benzene	n.r.	n.r. ^a	5.11E+03	n.r.	n.r.	n.r.	n.r.
CO	n.r. ^c	180	1.84E+07	1.12E+07	6.40E+06	8.14E+06	1.24E+07
CO ₂	1,840	1,367	4.00E+08	n.r. ^b	2.40E+08	1.49E+08	3.01E+08
HF	0.58	n.r. ^a	4.50E+04	3.58E+04	4.36E+04	3.12E+04	6.17E+04
F _{particulates}	0.44	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Ni and compounds	n.r.	n.r. ^a	n.r.	2.35E+02	n.r.	n.r.	n.r.
NMVOC	n.r.	n.r. ^a	1.15E+05	n.r.	n.r.	n.r.	n.r.
NO _x	0.6	n.r.	1.48E+05	n.r.	n.r.	n.r.	n.r.
PAH	0.065	n.r. ^a	n.r.	n.r.	n.r.	n.r.	n.r.
PFC ^c	0.178	0.099	3.83E+03	1.87E+04	2.80E+04	n.r. ^b	n.r. ^b
SO ₂	10.7	6.02	1.87E+06	5.63E+05	1.30E+06	7.19E+05	1.62E+06
Particulates ^d	2.5	n.r. ^a	8.12E+04	3.84E+05	6.97E+04	7.73E+04	8.51E+04
Zn and compounds	n.r.	n.r. ^a	n.r.	n.r.	n.r.	5.68E+02	n.r.

n.r.: no data reported; possible reasons: thresholds, inadequate measures

^aNot mandatory to report under UNFCCC

^bNot yet published by EPER—confidential data directly from supervisory authority (see Fig. 1)

^cConsists of approximately 90% CF₄ and 10% C₂F₆

^dReported by EPER as Dust_{PM10}

^eAccounted for as CO₂

Table 3 Emission factors for comparison, all in kg/Mg Al

Substance	EAA _{el} all (kg/Mg Al)	NIR	EPER _{pl}	EPER _{el}
CO	92.6	180	84.7	83
CO ₂	1,737	1,367	1,811	1,594
PFC	0.178	0.099	0.098	0.098
SO ₂	10.7	6.02	9.09	8.9

5 Discussion

The direct formation and emission of CO, CO₂ and SO₂ during the production of primary aluminium is inherently linked to the electrolysis process. CO and CO₂ are produced directly by the electrochemical *oxidation* of petroleum coke as the prior constituent of carbon anodes (Dittmeyer et al. 2006; International Aluminium Institute 2006a). The emission of SO₂ results from the sulphur content of petroleum coke (about 1%). During normal electrolysis, the major exhaust gas constituents are CO₂ (90–95%) and CO (10–5%) (Tabereaux 1994), whereas the CO₂/CO ratio is highly dependent on the current efficiency of the process (Grjotheim and Welch 1988; Hirt and Wilkening 1981). Modern Prebake technology is more efficient than older Söderberg technology (Grjotheim and Welch 1988). In contrast to CO, CO₂ and SO₂, PFCs are not formed during normal electrolysis conditions but only during a specific malfunction referred to as the ‘anode effect’. The production of PFCs during the anode effect is associated with a significant decrease of the CO₂/CO ratio. The anode effect is a periodic phenomenon that occurs randomly, in particular due to an undersupply of alumina inside the electrolyte (Tabereaux 1994). Furthermore, the frequency and duration of anode effects is also least for Prebake cells with modern computer-based alumina feeding.

Generally speaking, the emission levels decrease (1) the higher the share of modern smelter technology and (2) the younger the data. The scope of the EAA report corresponds to the European situation in 2002, which is based on a mix of the modern Prebake technology (85%) and the older Söderberg technology (15%). Emission factors from EPER and NIR correspond to the situation in Germany in 2004, which is characterised by a share of 100% Prebake technology. Knowing this, and in combination with the different system boundaries, one should assume that

- the emission factors from NIR are equal to those that have been calculated for EPER_{el},
- the EAA report provides the highest emission factors for CO, SO₂ and PFCs,

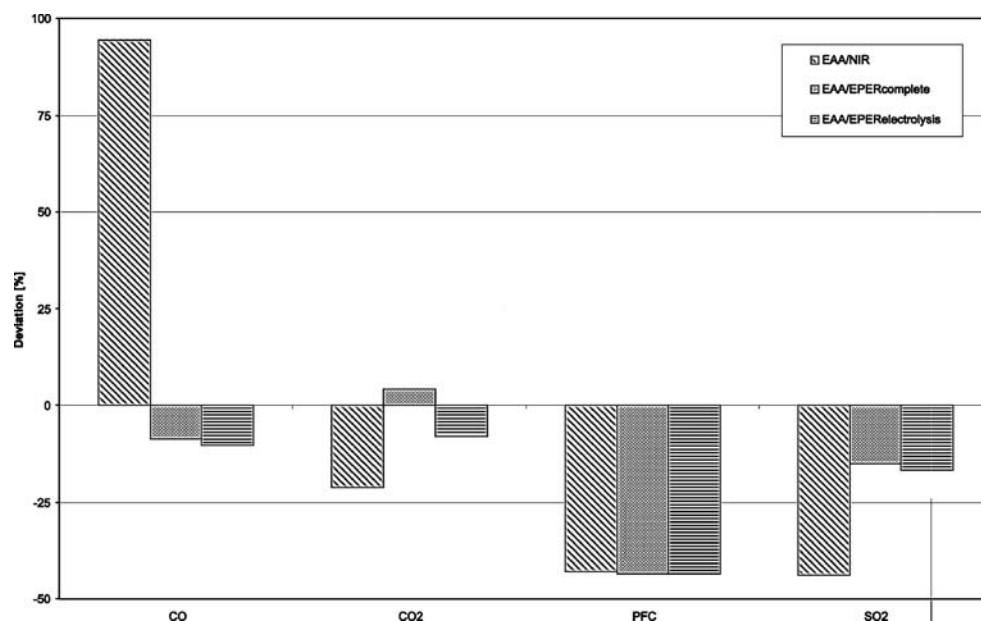
- the highest emission factor for CO₂ is reported by EPER_{pl}, followed by the values from EAA and NIR/EPER_{el} subsequently,
- the emission factors for PFCs from NIR, EPER_{pl} and EPER_{el} are equal, and
- the values for CO and SO₂ from EPER_{pl} are slightly higher than comparable measures from NIR.

The comparison of the data in Table 3 shows that the variation of the emission factors derived for EPER_{pl} and EPER_{el} confirm these qualitative assumptions. Furthermore, using the data from the EAA report as basis for comparison, the relative deviations between emission factors from EAA and EPER are within reasonable and acceptable margins (see Fig. 4). The significant decline of the emission factors for PFCs (45%) is accountable in particular for the improvements that have been made in the course of a voluntary agreement of the aluminium industry on the reduction of PFC emissions in the last years (International Aluminium, 2006b; Schwarz 2005a, b).

In contrast to this, the values that have been reported by NIR do not meet the qualitative assumptions. Only the emission factor for PFCs supports the expected result of being equal to the measures from EPER—even though there is a marginal difference that can be explained by rounding errors. In fact, the emission factors for CO₂ and SO₂ also represent rather small values—as could be expected. However, this qualitative fit is somewhat contradicted quantitatively by the grades of variance to the emission factors from the EAA study (CO₂ 21%, SO₂ 44%). There is no (technical) explanation for the decreased value for SO₂ from NIR. However, the latest NIR for Germany (Umweltbundesamt 2007) provides a modified emission factor of 10.4 kg SO₂/Mg Al. As no other emission factors were changed in this recent report, the emission factor for SO₂ from 2004 is assumed as being corrected, therefore. Finally, it must be assumed that the emission factors for CO and CO₂ from NIR do not correspond to the actual situation of electrolysis processes in Germany (Kirchartz 2007, personal communication). However, the mass balance of carbon for the electrolysis process is correct, at least.

The emission factors that have been derived from the EPER database indicate that it is not appropriate to use data from the EAA report to represent recent electrolysis operations in Germany. In fact, the actual emissions of PFCs from primary aluminium production in Europe reach values of 0.1 kg/Mg Al (Schäfer 2007, personal communication). However, that does not necessarily mean that the data from EAA are not representative within the system boundary and coverage they have been acquired originally. Thus, the dataset of EAA is judged to be reliable—within its original scope. Furthermore, for this example, it

Fig. 4 Matching of emission factors (as relative deviations from base of EAA)



becomes obvious that the emission factors that are provided by the NIR are not appropriate to be used as national reference data. From the LCA point of view, the use of NIR as a source for reference data must be seen as a drawback for the appropriateness, as its comparability is limited to greenhouse gases. Due to this, data from NIR allow an assessment of the appropriateness of existing data concerning only the impact on global warming potential (GWP). On the other hand the acquisition of emission factors from NIR is quite easier than the conversion of data from EPER. This derivation of emission factors is bound to the availability of site-specific production volumes that cannot be guaranteed in every case.

6 Conclusions and recommendations

From a LCA perspective, the referencing of generic LCI data provides an important informative basis to focus data collection and update. This study exemplifies drawbacks and opportunities of the usability of data from environmental reporting as a national reference for existing LCI data. By comparing selected emission factors from different sources, the magnitude of order of the deviation between the data from two environmental reports and related generic LCI data is specified. For this procedure, knowledge about temporal coverage and individual system boundaries of the data is required. Also, expert knowledge about the processes themselves and technologies applied within these is indispensable. Based on this knowledge, deviances can be explained and inappropriate or outdated data can be detected.

Both of the two reporting datasets used for this study have their respective advantages and disadvantages in this context. However, this consideration seems to be specific for the kind of system to be referenced. Right now, there is no measure to specify the appropriateness of one or another reporting obligation to be used as a source for reference data in advance. Furthermore, in this analysis, only a fraction of a complete process chain is covered. From the LCA point of view, it is desirable to increase the number of compared elementary flows and to integrate further stages in the process chain. Thus, further analysis will have to examine

- the transferability of the procedure to other examples, in order to enable a look at complete background LCI modules, and
- the usability of the increased number of elementary flows (e.g. as provided by EPER).

A promising perspective evolves from the upcoming European Pollutant Release and Transfer Register (PRTR). Parties which have consented the related PRTR protocol (United Nations Economic Commission for Europe 2003) will have to report releases and transfers of at least 86 pollutants to air, water and land such as GHG, acid rain pollutants, ozone-depleting substances, heavy metals and also off-site transfers of hazardous waste. As a protocol under the Aarhus Convention (United Nations Economic Commission for Europe 1998), it is characterised as an 'open' global protocol that is actually ratified by 38 parties, including the European Union. For Germany, reporting under the legislation of the PRTR will replace the EPER from 2009 onwards.

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